THE VALUE OF BARNYARD MANURE ON UTAH SOILS

By

F. S. HARRIS

BULLETIN NO. 172

Utah Agricultural College

EXPERIMENT STATION

Logan, Utah March, 1920

UTAH AGRICULTURAL EXPERIMENT STATION

EXPERIMENT STATION STAFF

E. G. PETERSON, Ph. D., President of the College

F. S. HARRIS, Ph. D.,........Director and Agronomist
WM. PETERSON, B. S.,........Geologist
H. J. FREDERICK, D. V. M.,........Veterinarian
F. L. WEST, Ph. D.,........Physicist
J. E. GREAVES, Ph. D.,........Chemist and Bacteriologist
W. E. CARROLL, Ph. D.,........Animal Husbandman
BYRON ALDER, B. S.,........Poultryman
GEORGE R. HILL, JR., Ph. D.,........Botanist
O. W. ISRAELSEN, M. S.,........Irrigation and Drainage Engineer
W. W. HENDERSON, M. S. A.,........Entomologist
M. C. MERRILL, Ph. D........Horticulturist
D. S. JENNINGS, Ph. D.,........Soil Survey
R. J. BECRAFT, B. S.,........Range Management
GEORGE STEWART, M. S.,........Field Crops
R. L. HILL, Ph. D.,........Human Nutrition
E. B. BROSSARD, Ph. D.,........Farm Management
C. T. HIRST, M. S.,........Associate Chemist
WILLARD GARDNER, Ph. D.,........Associate Physicist
B. L. RICHARDS, Ph. D.,........Associate Botanist
BLANCHE COOPER, B. S.,........Associate in Human Nutrition
GEORGE B. CAINE, M. A.,........Dairying
D. W. PITTMAN, M. S.,........Assistant Agronomist
EZRA G. CARTER, M. S.,........Assistant Bacteriologist
C. J. SORENSON, B. S.,........Assistant Entomologist
T. H. ABELL, M. S.,........Assistant Horticulturist
YEPPA LUND, B .S.,........Assistant in Chemistry and Bacteriology
I. J. JENSEN, B. S.,........Assistant Agronomist
L. F. NUFFER, B. S.,........Assistant Botanist
ARTHUR FIFE, B. S.,........Assistant in Irrigation
M. D. THOMAS, B. S.,........Assistant Agronomist
PETER NELSON, B. S.,........Farm Superintendent
N. E. EDLEFSEN, B. S.,........Assistant Physicist
G. E. KING, B. S.,........Assistant Entomologist
A. L. WILSON, B. S.,........Superintendent Davis County Farm
BLANCHE CONDIT PITTMAN, A. B.,........Clerk and Librarian
K. B. SAULS........Secretary to the Director

IN CHARGE OF CO-OPERATIVE INVESTIGATIONS WITH U. S. DEPARTMENT OF AGRICULTURE

L. M. WINSOR, B. S.,........Irrigation Engineer
A. F. BRACKEN, B. S.,........Assistant Agronomist

THE VALUE OF BARNYARD MANURE ON UTAH SOILS

By

F. S. HARRIS*

New countries rarely appreciate the value of barnyard manure. It is not until the soil begins to be depleted of its fertility and the yield of crops begins to decline that manure is given the attention that its value justifies. In new countries it is not uncommon to see manure hauled into a rut in the road or left in scattered heaps along the roadside or the ditch bank. Often a year's accumulation of manure is drawn out of the barn or corral in scrapers and added to a pile containing the accumulation of previous years.

As the development of the country progresses the rancher begins to feel himself in luck when he has a chance to get his yards cleaned for nothing. A nearby farmer hauls the manure to his own farm, receiving the manure for his trouble. The rancher is likely to consider himself particularly fortunate if he is able to get twenty-five or fifty cents a ton for the manure besides getting it out of the way. It is not usually until high-priced cash crops are raised that the farmer is made to realize how valuable manure really is.

The soils of Utah were considered unusually fertile and as a result the proper use of manure has been delayed as in all new countries. In regions of intensive agriculture, considerable demand has developed for manure; but most farmers have no very definite idea as to just what they could afford to pay for it.

It was with a view of getting definite information on the response of Utah soils to farm manure that the experiments reported in this bulletin were undertaken.

CONDITION OF THE EXPERIMENT

Most of the experiments herin reported were conducted on the irrigated farm of the Experiment Station at Greenville, two miles north of the Agricultural College. This is a deep, rather fertile limestone soil that is adapted to the raising of ordinary farm

*The author wishes to acknowledge his indebtedness to Messrs. A. E. Bowman, H. W. Stucki, H. J. Maughan, D. W. Pittman, J. W. Jones, and A. F. Bracken who conducted various parts of the field work reported herein and Mr. N. I. Butt who assisted in preparing the material for publication.

crops such as alfalfa, sugar-beets, potatoes, corn, and the small grains. Apples, berries, and garden crops also do well on this soil.

The chemical composition of the soil is shown in Table I and the precipitation on the farm during the years of the experiments

Table I. Chemical Composition of Greenville Loam Soil. (From Utah Experiment Station Bulletin 115, p. 202.)

Determination	Depth in Feet							
	1	2	3	4	5	6	7	8
Insoluble residue + silica	42.18	36.51	32.15	41.65	28.72	29.64	31.14	30.75
Potash (K_2O)	.67	.89	.59	.82	.61	.74	.79	.75
Soda (Na_2O)	.35	.47	.47	.62	.37	.42	.45	.74
Lime (CaO)	16.88	17.80	21.34	15.60	22.62	23.15	22.24	21.78
Magnesia (MgO)	6.10	9.46	7.57	7.48	9.36	5.89	6.06	5.63
Oxide of Iron (Fe_2O_3)	3.03	2.69	3.46	2.95	2.17	2.42	2.47	2.54
Alumina (Al_2O_3)	5.64	4.69	3.40	6.09	5.33	8.07	7.90	9.03
Phosphoric Acid (P_2O_5)	.41	.29	4.34	.19	.12	.06	.07	.11
Carbon dioxide (CO_2)	19.83	23.11	26.67	20.88	29.31	29.57	28.80	28.13
Volatile matter	5.60	3.38	3.93	4.23	.91	.95	....	.24
Total	100.69	99.29	99.93	100.51	99.52	100.91	99.92	99.68
Humus	.53	1.00	.61	.47	1.13	.60	.44	.57
Nitrogen	.14	.12	.08	.18	.07	.07	.06	.07

in Table II. The farm has been irrigated with water from Logan River, the composition of which is given in Table III.

The amount of water applied has varied with the season and the crop, but probably an average of about one and a half acre-feet have been applied each year. In several of the experiments the exact amount of water used in each case is reported.

The experiments under dry-farming were carried on at Nephi, Juab County, on clay loam soil that is well adapted to raising the

Table II. Monthly and Annual Precipitation at Logan During the Years of the Experiments.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1911	5.76	1.46	2.72	1.48	1.77	.29	.12	.00	1.92	1.14	1.70	.71	19.07
1912	.95	.93	2.02	2.25	2.22	.91	1.98	1.31	.54	3.04	2.40	.35	18.90
1913	.69	.92	3.09	1.65	1.25	2.09	1.98	.14	1.47	2.14	1.84	.56	17.82
1914	3.80	1.40	1.73	2.32	.86	3.15	1.98	.08	1.51	2.21	.00	.55	19.59
1915	1.06	1.32	.59	1.94	3.28	1.12	.22	T	3.44	.05	1.37	.78	15.17
1916	2.61	2.62	2.17	1.73	.91	.88	.08	.20	.10	3.78	.80	2.89	18.77
1917	.91	4.51	1.88	2.84	4.21	.48	.48	.00	1.34	.07	.77	.65	18.14
1918	3.15	2.33	1.80	.80	1.82	.44	1.14	.36	1.22	2.56	.94	.35	16.91
1919	.02	1.88	.74	1.62	1.20	.00	.31	.40	2.88	4.43	.73	1.49	15.70
Average	2.11	1.93	1.86	1.85	1.95	1.04	.92	.28	1.60	2.16	1.17	.93	17.79

small grains. The chemical composition of this soil is shown in Table IV. The precipitation at Nephi during the years of the experiment is shown in Table V.

Table III. Chemical Composition of Water from Logan River at Different Dates. (From Utah Experiment Station Bulletin 115, p. 204.)

Determination	1901		1902		
	June 13	Aug. 8	July 14	Aug. 4	Aug. 9
Total Residue	175	205	368	345	367
Non-Volatile	115	155	267	248	234
Loss on ignition	60	50	101	97	133
Silicia (SiO_2)	5	4	5		9
Lime (CaO)	32	29	34		30
Magnesium (MgO)	23	27	40		45
Phosphoric Acid (P_2O_5)	4	T			
Sulphuric Acid (SO_3)	7	11			
Potash (K_2O)	1.3	2.1			
Chlorine (Cl)	T	17			
Undetermined	99	110			
Carbon Dioxide (CO_2)	108	54			

In all these experiments the manure was mixed, coming from horses and cattle fed largely on alfalfa hay. It accumulated in piles during the summer and was usually spread over the land in the fall before plowing.

Table IV. Chemical Composition of Soil from the Nephi Experiment Farm. (From Utah Experiment Station Bulletin 122, p. 284.)

Determination	Depth in Feet			
	1	3	4	9
Insoluble Residue	73.12	62.10	62.00	65.69
Potash (K_2O)	1.31	.91	.67	.70
Soda (Na_2O)	.14	.18	.52	.68
Lime (CaO)	4.27	11.05	12.34	11.83
Magnesia (MgO)	1.82	1.80	2.66	2.93
Sulphuric Acid (SO_3)	.13	.12	.17	.07
Oxide of Iron (Fe_2O_3)	3.92	3.61	2.26	2.36
Alumina (Al_2O_3)	6.33	6.43	5.05	3.36
Phosphoric Acid (P_2O_5)	.42	.47	.36	.26
Carbon Dioxide (CO_2)	2.16	9.10	10.74	10.09
Volatile Matter	5.31	4.35	2.79	2.57
Humus	1.54	1.99	1.56	1.15
Nitrogen	.12	.10	.04	.05
Total Phosphorus	.19	.22	.18	.11
Total Potassium	2.32	1.75	1.48	1.30

Table V. Monthly and Annual Precipitation at Nephi During the Years of the Experiment.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1915	1.22	2.25	.98	1.50	3.21	1.04	.02	.21	1.30	.49	.90	.60	13.72
1916	1.95	1.75	2.96	.28	.96	.00	1.14	.78	.50	2.54	.20	1.26	14.32
1917	.24	.90	.33	1.46	3.28	.21	.44	.29	.81	.07	1.06	.54	9.63
1918	1.95	.72	1.04	.89	.96	1.54	1.77	.06	1.16	.96	1.62	.82	13.49
1919	.00	.67	.95	.75	.95	.00	.54	.75	2.39	1.47	.69	.40	9.56
Average	1.07	1.26	1.25	.98	1.87	.56	.78	.42	1.23	1.11	.89	.72	12.14

EXPERIMENTS WITH SUGAR-BEETS

At the Greenville farm the east field has not received manure since the farm was established in 1902, whereas the west field has been manured practically every year during this period. Table VI shows a comparison of the yield of sugar-beets produced on 12 unmanured plats in the east field and 4 manured plats in the west field. The soil is the same in both fields. The land was plowed, irrigated, and treated approximately the same in every respect on the average during the years of the experiment except the manuring. Each year of the experiment approximately 10 tons of manure to the acre were applied to the manured plats. Table VI shows an average yield of 6.94 tons of beets on the unmanured plats as compared with 19.75 tons on the manured plats or an increase of 12.81 tons to the acre as a result of the manure. It must be remembered, however, that this is not due entirely to the manure applied during the four years of the experiment since manuring had been practiced for many years previously and the unmanured plats had received no fertilizer since 1902.

Table VI. Yield of Sugar-Beet Roots and Tops in Tons to the Acre on 12 Unmanured Plats and 4 Manured Plats With Increase Due to Manuring During Four Years.

Year	Yield in tons per acre				Increase in yield due to manure				Per cent of Roots	
	Roots		Tops		Roots		Tops			
	Unmanured	Manured...	Unmanured	Manured...	Tons........	Per Cent...	Tons........	Per Cent...	Unmanured Land........	Manured Land........
1916	8.27	20.35	5.42	9.19	12.08	146.0	3.77	69.55	60.41	68.89
1917	6.96	20.95	6.07	7.88	13.99	201.0	1.81	29.81	53.42	72.67
1918	7.89	23.90	5.93	11.18	16.01	202.9	5.25	88.53	57.09	68.13
1919	4.66	13.81	3.09	9.68	9.15	196.3	6.59	213.20	60.13	58.79
Average ..	6.94	19.75	5.12	9.48	12.81	186.55	4.36	100.27	57.76	67.12

An examination of the table reveals the fact that on manured land more roots are produced in proportion to tops than where no manure is applied. The yield of tops must not, however, be given so much attention as the yield of roots, since it was during some years rather difficult to get the exact weight of tops when storms occurred during harvest.

The effect of season is rather marked. For example, in 1919 a poor yield was secured on all plats. This was due to an unfavorable spring which made it impossible to get a good stand.

Table VII. Yield of Sugar-Beet Roots and Tops on Plats Receiving No Manure, 10 Tons, and 30 Tons to the Acre Each Year for Four Years.

Year	Yield in Tons per Acre						Per Cent of Roots		
	Roots			Tops					
	No Manure	10 Tons Manure	30 Tons Manure	No Manure	10 Tons Manure	30 Tons Manure	With No Manure	With 10 Tons Manure	With 30 Tons Manure
1916	5.76	9.25	11.88	4.37	4.11	4.88	56.86	69.24	70.88
1917	8.96	18.51	20.70	6.36	9.49	12.74	58.49	66.11	61.88
1918	9.12	23.59	27.22	6.06	6.48	12.37	60.08	78.45	68.75
1919	6.06	20.77	22.16	4.09	7.97	10.99	59.70	72.26	66.85
Average	7.47	18.03	20.49	5.22	7.01	10.25	58.86	72.00	66.66

INCREASE IN YIELD OF BEETS DUE TO MANURE

Year	10 Tons Manure			30 Tons Manure		
	Tons Beets	Tons Beets per Ton of Manure	Per Cent Increase	Tons Beets	Tons Beets per Ton of Manure	Per Cent Increase
1916	3.49	.349	60.6	6.12	.204	106.2
1917	9.55	.955	106.6	11.74	.391	131.0
1918	14.47	1.447	158.7	18.10	.603	198.5
1919	14.71	1.471	242.7	16.10	.537	265.7
Average	10.56	1.056	142.2	13.01	.434	175.4

Another experiment to determine relative effect of different quantities of manure on the yield of sugar-beets was conducted on the Greenville farm from 1916 to 1919 inclusive. Plat 44-G had 30 tons of manure to the acre applied each year in the fall before plowing, plat 45-G had 10 tons applied in the same manner, and plat 46-G was unmanured. Previous to the beginning of the experiment the land had been unmanured for at least 14 years. Fifteen inches of irrigation water each season were applied to all plats. The results are shown in Table VII.

Part of the material of Table VII is shown graphically in Fig. 1. An examination of this table and figure shows a rather striking effect of manure on the yield of beets. During the first year the manure had caused some increase, although not so

much as later. The increase in yield due to 10 tons is only 60 per cent during the first year whereas it is 242 per cent at the end of the fourth year when more manure had accumulated in the soil.

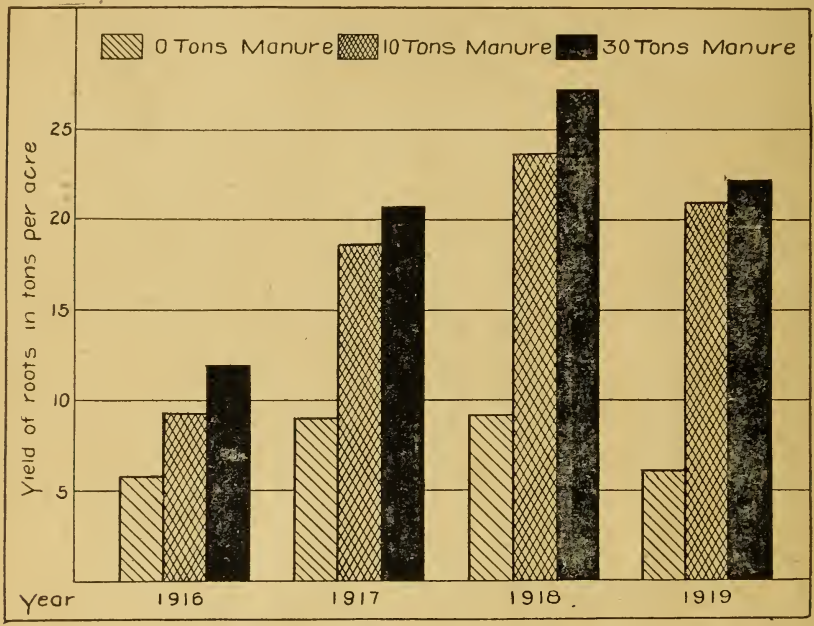

Fig. 1.—The effect of annual manurings of 10 and 30 tons on the yield of sugar-beets for the first four years.

During the first year the 30-ton application gave a yield considerably larger than the 10 tons, but after four years the difference was not so great between the two manurings. The difference between the unmanured and the manured plats was much greater than at first, however.

As an average of the four years there was an increase in yield of more than one ton of beets for each ton of manure applied for the 10-ton application and nearly a half a ton of beets for each ton of manure in the 30-ton application. The smaller quantity of manure is seen to be much more effective for each ton than the larger application.

In two rotation systems on the Greenville farm in which sugar-beets were included, one received no manure, whereas in the other 15 tons of manure to the acre were applied in the fall before each beet crop. The rotation receiving no manure was as follows: Wheat, potatoes, potatoes, peas, sugar-beets, and sugar-beets. The rotation in which manure was applied was as follows:

Oats with alfalfa, alfalfa, alfalfa, alfalfa, oats, sugar-beets, and sugar-beets. In this rotation the manure was applied before each crop of beets. This gives a combination of beets grown on land that has received but one manuring as well as on land that has been manured during two years.

Table VIII. Yield of Sugar-Beets on Unmanured Land and on Land Receiving One and Two 15-Ton Applications of Manure.

Year	Unmanured		Manured the Previous Fall		Manured the Two Falls Previous		Increase in Yield in Tons per Acre	
	Plat No.	Yield	Plat No.	Yield	Plat No.	Yield	For One Manuring	For Two Manurings
1913	55,56	5.32	27-G	12.25	26-G	11.05	6.93	5.73
1914	54,55	11.15	21	16.14	27	18.67	4.99	7.52
1915	53,54	6.79	22	14.82	21	18.49	8.03	11.70
1916	52,53	4.71	23	18.21	22	22.34	13.50	17.63
1917	51,52	6.52	24	19.47	23	20.44	12.95	13.92
1918	51,56	7.88	25(a)	21.60	24	25.43	13.72	17.55
1919	55,56	6.73	26(b)	17.43	25(c)	18.42	10.70	11.69
Av'rg.		7.01		17.13		19.26	10.12	12.25

(a) Manured once 6 years before, (b) Manured 6 and 7 years before also, (c) Manured once 7 years before.

The results of this work are shown in Table VIII and Figure 2. The increase in yield due to the manure is shown graphically in Figure 2. The table and figure show distinctly the value of

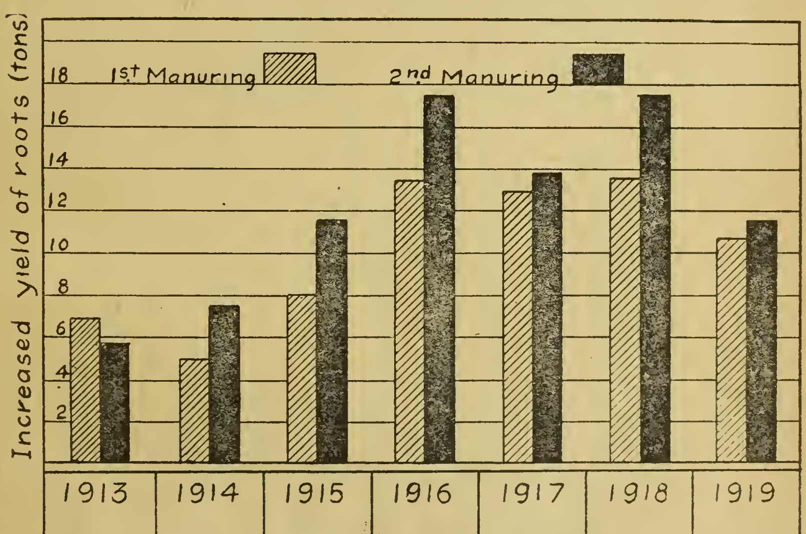

Fig. 2.—The increase in yield of beets due to manure added to the first of two years' sugar-beet crops compared with the crop following which had received a second manuring.

manure even when the beets are raised in a rotation with alfalfa. The alfalfa alone was not sufficient to keep the land producing at its highest. Some farmers have an idea that if they can only rotate with alfalfa it is not necessary to use manure. The folly of this point of view is brought out by this experiment,

Table IX. Yield of Sugar-Beets on Land Receiving Various Quantities of Manure.

Manure Added	Yield Tons per Acre		Increase Due to Manure		Increase in Tons of Beets for Each Ton of Manure
	Roots	Tops	Roots	Tops	
None	6.27	4.51	....	....	....
5 Tons..	16.01	7.74	9.74	3.23	1.948
10 Tons..	18.03	7.01	11.76	2.50	1.176
15 Tons..	19.22	9.31	12.95	4.80	.863
30 Tons..	20.49	10.25	14.22	5.74	.474
40 Tons..	22.13	14.94	15.86	10.43	.397

In order to test the effect of a considerable variation in the rate of applicataion of manure on the yield of sugar-beets an experiment was conducted with no manure, 5 tons, 10 tons, 30 tons, and 40 tons per acre annually. The land had received these quantities several years before the beets were planted. The results, which are shown in Table IX and Figure 3 represent the average yields for the years 1918 and 1919 for the 5-ton, the

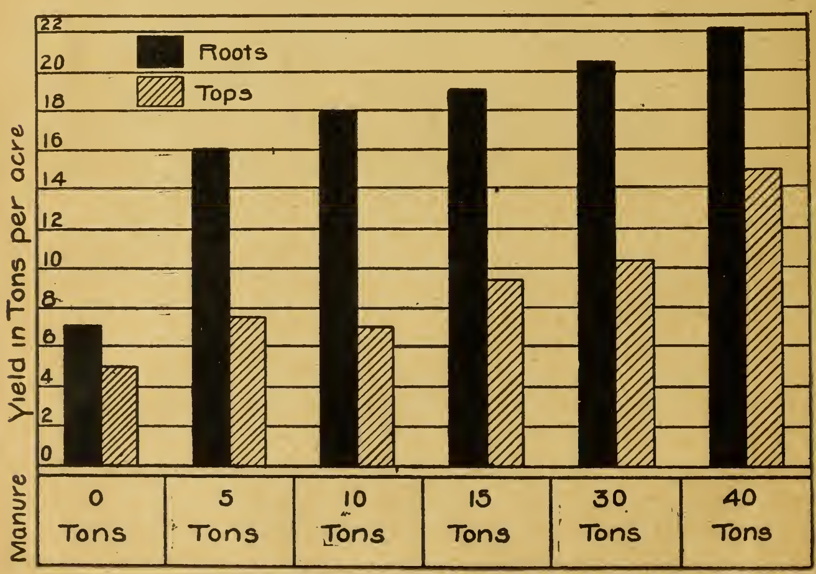

Fig. 3.—The influence of different quantities of manure upon the yield of roots and tops of sugar-beets.

15-ton and the 40-ton applicataions and the four years, 1916 to 1919, for the other applications.

The table shows an increase in yield of beets with an increase in manure application up to 40 tons annually. The increase per ton of manure is greater with the lower application and gradually decreases as the quantity of manure increases. With a 5-ton annual application each ton of manure increased the production of beets by nearly two tons.

EXPERIMENTS WITH POTATOES

In order to determine the value of manure on the yield of potatoes a comparison was made between twenty plats of potatoes produced on land receiving about 10 tons of manure to the acre each fall with two plats that have not received manure for at least ten years before the experiment began. The unmanured plats were in the following rotation: wheat, potatoes, potatoes, peas, beets, and beets. The manured plats alternated beets with potatoes one year each. The results are shown in Table. X.

Table X. Yield of Potatoes on Land Unmanured and Manured at the Rate of About 10 Tons to the Acre Each Year.

Year	Yield of Potatoes in Bushels per Acre		Increase in Yield Due to the Manure
	Unmanured	Manured	
1912	163.4	468.3	304.9
1913	179.0	327.7	148.7
1914	117.9	227.4	109.5
1916	109.2	218.7	109.5
1917	162.8	148.8	--------
1918	145.8	152.5	6.7
1919	177.9	240.8	62.9
Average......	150.8	254.8	104.0

An examination of Table X shows a marked increase in yield due to manure during the early years of the experiment with less difference later. It seems very likely that the reason the yields on the manured and unmanured plats during 1917 and 1918 were about the same was that these years were not favorable to the growth of potatoes and that factors other than soil fertility interfered with the experiment.

The alternate raising of potatoes and beets did not give the land sufficient time between potato crops to control diseases, whereas the longer rotation on the unmanured plats was more favorable in this respect. The increase in disease in the soil doubtless accounts largely for the rapid decrease in the yield on the manured plats.

An experiment to determine the effect of various quantities of manure on the yield of potatoes was conducted during three years. The manured plats received the quantities specified in Table XI annually. The irrigation consisted of 2½ inches of water applied each week during the irrigating season. The same results are expressed graphically in Figure 4.

Table XI. Yield of Potatoes on Land Receiving Various Quantities of Manure.

Manure	Yield in Bushels per Acre				Increase due to Manure		
	1910	1911	1915	Average	Bushels	Per Cent	Bushels for Each Ton of Manure
None	140.9	124.7	94.0	119.9	....	....	....
5 Tons	224.0	118.8	140.5	184.4	64.5	53.8	12.9
15 Tons	261.7	218.3	206.4	228.8	108.9	90.8	7.3
40 Tons	328.5	245.5	298.7	290.8	171.0	142.6	4.3

An examination of this table and figure shows that the yield was directly proportional to the amount of manure applied, but that the increase for each ton of manure applied decreased as the quantity applied increased. Where the manuring was 5 tons to the acre each ton increased the yield of potatoes 12.9 bushels to the acre, whereas 40 tons to the acre only gave an increase of 4.3 bushels for each ton of manure.

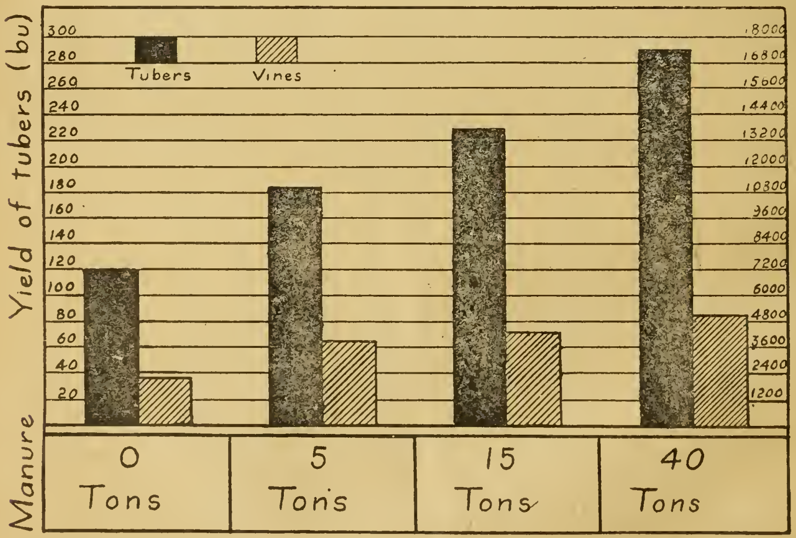

Fig. 4.—The influence of different quantities of manure upon the yield of potato tubers and vines.

EXPERIMENT WITH WHEAT

The value of manure for wheat was tested in an experiment which included plats receiving no manure and three different

Table XII. Yield of Wheat and Straw on Plats Receiving Different Quantities of Manure During Three Years

Manure Added	Yield of Grain in Bushels per Acre				Yield of Straw in Pounds per Acre				Increase in Yield Due to Manure			
									Bushels Grain	Pounds Straw	For Each Ton of Manure	
	1912	1913	1914	Av'g	1912	1913	1914	Av'g			Bu. Grain.	Lbs. Straw..
None	42.0	40.6	31.6	38.1	6486	4454	3637	4859	......	....	....	....
5 Tons	64.0	42.6	37.8	48.1	7178	4875	5336	5796	10.0	937	2.00	187
15 Tons	69.0	54.0	42.4	55.1	8006	5705	6219	6643	17.0	1784	1.13	119
40 Tons	62.0	57.1	35.1	51.4	5624	6786	7405	6605	13.3	1746	.33	44

quantities applied annually. The experiment extended over three years. In each case 2½ inches of irrigation water were applied each week during the irrigation season. New Zealand was the variety used. The results are given in Table XII and Figure 5.

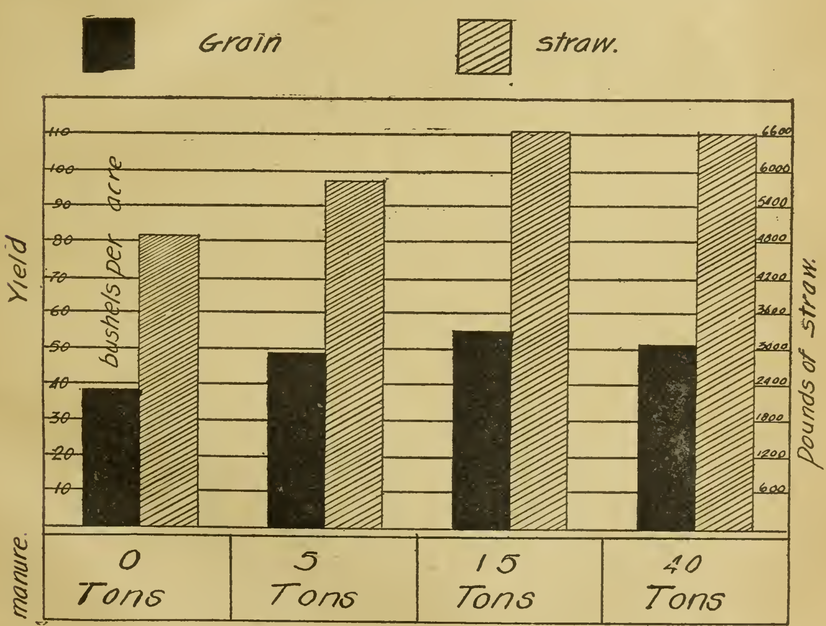

Fig. 5.—Effect of manure on the yield of wheat—grain and straw.

An examination of the table and figure shows an increase in yield of grain with an increase in manure with 5 and 15 tons, but when as much as 40 tons were applied annually the straw grew so rank that it lodged and the yield did not increase as much as for less manure. An increase of two bushels of wheat for each ton of manure was secured where 5 tons to the acre were applied annually.

EXPERIMENTS WITH OATS

An experiment similar to that reported for wheat was conducted for oats on the same plats with the same treatments during later years. These results which are reported in Table XIII and Figure 6 are not unlike those for wheat except that the returns for each ton of manure were even less than for wheat.

Table XIII. Yield of Oats and Straw on Plats Receiving Different Quantities of Manure During Two Years

Manure Added	Yield of Grain in Bushels per Acre			Yield of Straw in lbs. per Acre			Increase in Yield Due to Manure			
							Bushels Grain	Pounds Straw	For Each Ton of Manure	
	1916	1917	Av'g.	1916	1917	Av'g.			Bu. Grain	Lbs. Straw
None	101.3	56.0	78.65	2569	2056	2312	....	....	......	....
5 Tons	90.6	83.2	86.90	4743	6668	5705	8.25	3393	1.65	679
15 Tons	103.8	89.8	96.80	5956	7404	6680	18.15	4368	1.21	291
40 Tons	114.5	71.6	93.05	9513	9038	9275	14.40	6963	.36	174

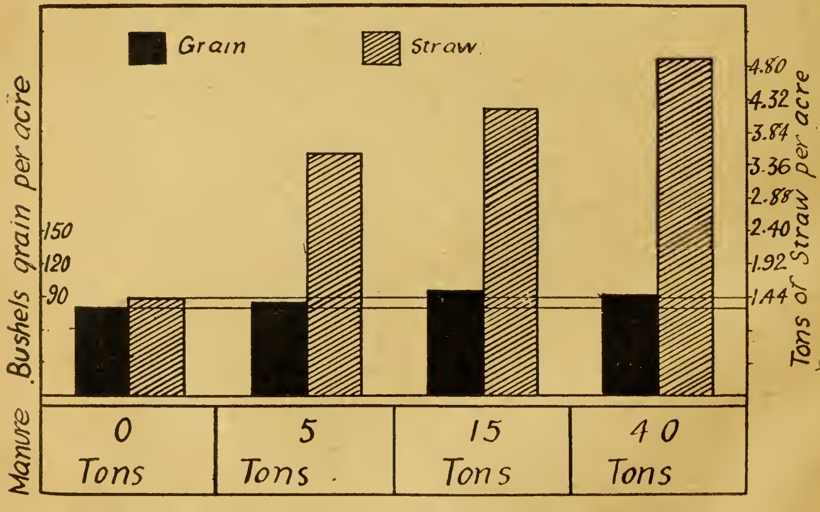

Fig. 6.—Effect of manure on yield of oats—grain and straw.

RESULTS WITH CORN

An experiment on the value of manure for corn was conducted during the nine years from 1911 to 1919 inclusive and embraced 36 plats, or twelve for each manuring treatment. The same irrigation treatments were given for each manuring. Of the twelve plats in each manuring treatment, two received no irrigation and two received each of the following quantities of irrigation water during the season: five, ten, twenty, thirty, and forty inches. This made a very complete set of treatments. Twelve plats received no manure, twelve were given 5 tons, and twelve

Table XIV. Yield of Corn and Stover with No Manure, 5 Tons, and 15 Tons annually to the Acre During 9 Years. Average of 12 Plats in Each Case

Year	Bushels per Acre			Bushels per Acre Increase Due to Manure		Bushels of Grain Increase per Acre for Each Ton of Manure	
	No Manure	5 Tons Manure	15 Tons Manure	For 5 Tons Manure	For 15Tons Manure	With 5 Tons	With 15 Tons
1911 ..	64.3	72.1	86.7	7.8	22.4	1.56	1.49
1912 ..	60.2	86.9	95.4	26.7	35.2	5.34	2.35
1913 ..	71.4	103.5	115.0	32.1	43.6	6.42	2.91
1914 ..	61.5	83.1	91.1	21.6	29.6	4.32	1.97
1915 ..	50.0	75.8	73.4	25.8	23.4	5.16	1.56
1916 ..	59.8	82.9	83.5	23.1	23.7	4.62	1.58
1917 ..	78.7	94.3	99.1	15.6	20.4	3.12	1.36
1918 ..	81.3	102.3	108.2	21.0	26.9	4.20	1.79
1919 ..	60.2	59.0	52.3	–1.2	–7.9	–.24	–.53
Av'g. ..	65.3	84.4	89.4	19.2	24.1	3.83	1.61

YIELD OF STOVER

Year	Pounds per Acre			Pounds per Acre Increase Due to Manure		Pounds Increase in Stover per Acre for Each Ton of Manure	
	No Manure	5 Tons Manure	15 Tons Manure	For 5 Tons Manure	For 15 Tons Manure	With 5 Tons	With 15 Tons
1911 ..	3958	4766	6128	808	2170	162	145
1912 ..	4614	7467	9687	2853	5073	571	338
1913 ..	4854	8832	10538	3978	5684	796	379
1914 ..	7974	10954	11332	2980	3358	596	224
1915 ..	4322	6670	7918	2348	3596	470	240
1916 ..	5361	7443	7974	2082	2613	416	174
1917 ..	7390	9764	10266	2374	2876	475	192
1918 ..	6139	7503	9404	1364	3265	273	218
1919 ..	4397	4862	4667	465	270	93	18
Av'g. ..	5445	7585	8657	2139	3212	428	214

received 15 tons to the acre each year. The results of this experiment are shown in Table XIV and Figures 7 and 8.

Fig. 7.—Effect of manure upon the yield of ear corn when irrigated with different quantities of irrigation water.

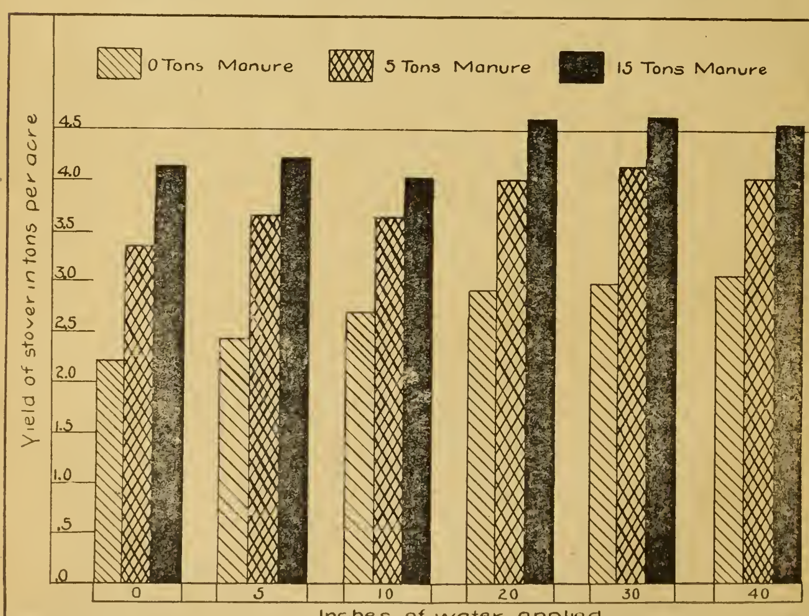

Fig. 8.—Effect of manure upon the yield of corn stover when irrigated with different quantities of irrigation water.

An examination of Table XIV shows an average increased yield of corn of 19.2 bushels for 5 tons manure and 24.1 bushels for 15 tons manure or 3.83 and 1.61 bushels of grain respectively for each ton of manure. This is the average of 9 years' results. During one year there was an increase of 6.42 bushels for each ton of manure applied. There was also a corresponding increase in the yield of stover. Figures 7 and 8 show in a graphical way the increase in yield of grain and stover with each quantity of irrigation water applied from 5 to 40 inches.

RESULTS UNDER DRY-FARMING

There has been a popular idea through the country that manure was of no value on the dry-farm. In fact it is thought

Table XV. Yield of Turkey Red Wheat as Affected by Manure Under Dry-Farming During Five Years

Plat Numbers	Tons of Manure Applied per Acre	Bushels of Grain per Acre						Average Increase in Bushels per Acre Due to Manure
		1915	1916	1917	1918	1919	A'vg.	
6 plats	No Manure.........	10.9	15.0	27.9	14.7	21.1	17.9	......
12,28	2.5 every 4 years	10.9	15.1	26.8	16.5	22.5	18.4	.5
13,29	5.0 every 4 years	11.8	18.2	29.1	16.3	23.3	19.7	1.8
14,30	10.0 every 4 years	13.5	18.1	30.5	15.2	25.0	20.5	2.6
16,32	1.0 each alt. year	10.6	14.9	27.5	16.3	20.8	18.0	.1
17,33	2.5 each alt. year	9.8	15.2	27.0	14.8	22.3	17.8	.1
18,34	5.0 each alt. year	11.7	15.1	30.0	16.2	25.0	19.6	1.7
19,35	10.0 each alt. year	13.4	17.8	30.3	18.4	26.2	21.2	3.3
21,37	2.5 1st year only	11.9	15.5	30.1	17.2	23.3	19.4	1.5
22,38	5.0 1st year only	12.7	17.1	32.4	15.3	23.9	20.3	2.4
23,39	10.0 1st year only	13.1	17.2	28.8	16.4	23.0	19.7	1.8
24,40	15.0 1st year only	13.6	21.9	31.0	16.8	22.5	21.2	3.3
25,41	20.0 1st year only	13.7	20.0	29.8	16.0	24.0	20.7	2.8

STRAW

Plat Numbers	Tons of Manure Applied per Acre	Pounds of Straw per Acre						Average Increase in Pounds per Acre Due to Manure
		1915	1916	1917	1918	1919	A'vg	
6 Plats	No Manure.........	647	1058	1803	490	1660	1132	......
12,28	2.5 every 4 years	540	955	1760	535	1580	1074	–58
13,29	5.0 every 4 years	660	1125	2150	585	1900	1284	152
14,30	10.0 every 4 years	760	1050	2170	515	1950	1289	157
16,32	1.0 each alt. year	590	925	1810	535	1690	1110	–22
17,33	2.5 each alt. year	550	925	1825	462	1700	1092	40
18,34	5.0 each alt. year	625	1045	2055	525	2020	1254	122
19,35	10.0 each alt. year	695	1140	2230	605	1990	1332	200
21,37	2.5 1st year only	635	940	1960	570	1730	1167	35
22,38	5.0 1st year only	755	990	2245	530	1920	1288	156
23,39	10.0 1st year only	560	975	2050	520	1860	1193	61
24,40	15.0 1st year only	720	1825	2260	535	1850	1438	306
25,41	20.0 1st year only	705	1255	2160	540	1750	1282	150

by many to be actually injurious by making crops burn when moisture is short. As a result much manure on dry-farms that could very easily be spread over the land is allowed to go unused.

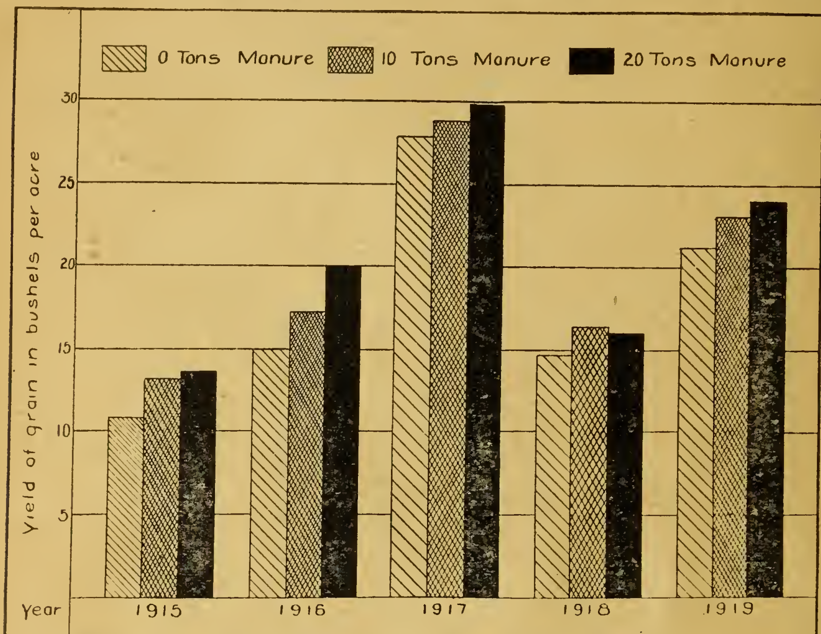

Fig. 9.—Residual effect of manure on wheat under dry-farm conditions.

In order to secure more definite knowledge on this point, experiments on the use of manure under dry-farming were begun in 1915. Five years' results are now available. The experiment calls for the following treatments: (1) 2½ tons to the acre once every four years, (2) 5 tons once every four years, (3) 10 tons once every four years, (4) 1 ton each alternate year, (5) 2½ tons each alternate year, (6) 5 tons each alternate year, (7) 10 tons each alternate year, (8) 2½ tons first year only, (9) 5 tons first year only, (10) 10 tons first year only, (11) 15 tons first year only and (12) 20 tons first year only. Each of these treatments is given in duplicate. This gives the complete series cropped and also fallow each year. The results of this work are given in Table XV.

An examination of Table XV shows that while the increased yield of wheat was not great as a result of the use of manure, still there was a distinct increase. There was an increase of 3.3 bushels to the acre when 10 tons each alternate year were applied. The same average increase during 5 years was noted where 15 tons of manure were applied only at the beginning. It

seems evident that under dry-farming the returns for manure will not be so immediate as under irrigation; the returns may come in during later years. This is brought out graphically in Figure 9.

CARE OF FARM MANURE

Experience has demonstrated that the best way to handle farm manure is to spread it on the land when fresh. This prevents any serious loss from either leaching or fermentation. Care should be taken to have all liquid absorbed instead of allowing it to go to waste since it is pound for pound equal to the solid manure in plant food value. Many farmers haul manure to the field and leave it standing for months in small piles. This is not a good practice, since its loose condition allows destructive fermentation to go on readily. Moreover the leaching of the piles causes an irregular distribution of plant food over the field.

During parts of the year there is no vacant land on which manure can be spread, hence it must be stored or piled. This can be done in special manure pits, under sheds, or in the open yard. Expensive pits probably do not pay on the average farm, but simple devices to assist in handling manure are without doubt a good thing.

It has already been stated that by proper piling the loss due to leaching and fermentation can be practically overcome. Where an open yard is used the neatest and most sanitary kind of pile,

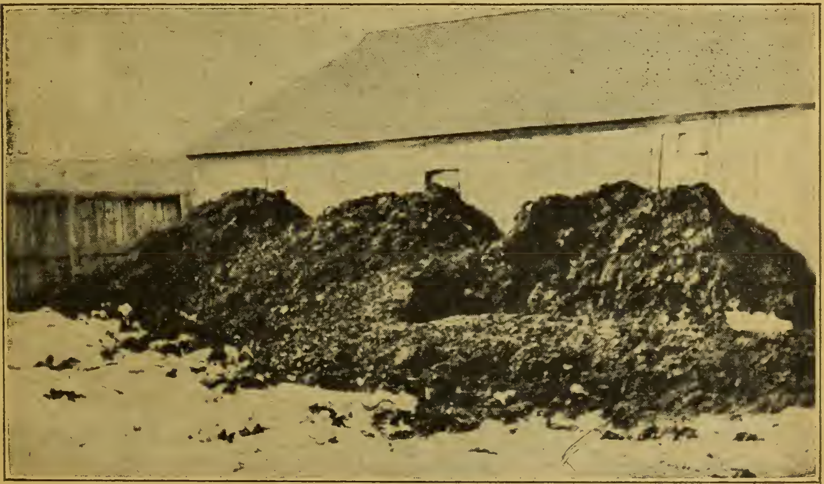

Fig. 10.—Poor way of piling manure. Drippings from the eaves will leach out valuable salts, and the loose condition of the pile favors loss of nitrogen by fermentation.

Fig. 11.—A fairly well built manure pile.

as well as the one allowing the least loss, is a square pile with vertical sides and with edges slightly higher than the middle. The manure that is produced each day should be on the pile by night. The two things that must be kept constantly in mind are to keep the pile compact and moist. Tramping and the addition of water may be necessary to maintain these conditions. A little attention in this way to the manure pile will yield handsome returns for all time spent.

The manure spreader is a great time saver and it makes possible a more even distribution than can be made by hand.

RESIDUAL EFFECTS OF MANURE

Fig. 12.—The sleigh provides a convenient means of putting the manure directly on the land in winter.

In order to test the value of manure during the several years after it is applied various treatments were examined. The first to be considered is the data given in Figure 9 taken from the dry farm experiment described above. The 10 and 20 tons to the acre of manure were applied to the 1915 crop and no manure was applied during succeeding years. The chart shows that the effect of the

manure is distinct after five years. The second year it is even more beneficial than the first. It will be remembered in this connection that on account of the low moisture content of the soil, manure decays slowly in dry farm soils.

SUMMARY

1. This bulletin reports results of experiments on the value of farm manure in increasing the yield of various crops on irrigated and dry-farm soils.

2. The idea sometimes expressed that Utah soils are so fertile that they do not need manure, is certainly not borne out by these experiments.

3. Manure applied to sugar-beets at the rate of ten tons to the acre gave an increase in yield of about one ton of beets for each ton of manure. Five tons to the acre gave nearly two tons of beets for each ton of manure, but where as much as forty tons to the acre were applied the increase was only about .4 of a ton of beets for each ton of manure.

4. Where potatoes were manured at the rate of 5 tons to the acre the yield was increased by nearly 13 bushels for each ton of manure, but where 40 tons were applied the increase was only 4.3 bushels for each ton.

5. Manure applied to wheat gave an increased yield of 2 bushels for each ton of manure where 5 tons were applied, 1.13 bushels where 15 tons were applied and only .33 bushels for each ton of manure where 40 tons were applied.

6. Manure applied to oats gave an increase of 1.65, 1.21, and .36 bushels of grain respectively for each ton of manure when 5, 15, and 40 tons of manure to the acre were applied.

7. The average of nine years of manure applied to corn gave an increase of 3.83 bushels of grain and 428 pounds of stover, and 1.61 bushels of grain and 214 pounds of stover respectively for each ton of manure when 5 and 15 tons were applied to the land each year.

8. The use of farm manure under dry-farming conditions does not seem to be so immediately profitable as under irrigation, the residual effect of manure under dry-farming is very marked.

9. The use of manure on expensive crops such as sugar-beets and potatoes gave a higher return for each ton of manure than when it was applied to wheat and oats.

10. These experiments bring out clearly the fact that manure is much more valuable on Utah soils than it is usually thought to be.

(College Series No. 143)